NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
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FOR RELEASE: Wednesday AM's
June 1, 1960

RELEASE NO. 60-215

NASA NEGOTIATES FOR 200,000-POUND-THRUST ENGINE

The National Aeronautics and Space Administration will negotiate a contract with Rocketdyne, a division of North American Aviation, Inc., for development of a 200,000-pound-thrust liquid hydrogen-fueled engine.

The Canoga Park, Calif., firm's proposal was one of five received by NASA in a competition which ended March 14. Rocketdyne estimates development of the new engine will take about three years and cost some $44 million.

The engine may be used in clusters of two or four to power upper stages of advanced configurations of Saturn. Initially, the engine will be a single-start engine but can be modified readily to make it capable of multiple starts in flight.

Use of liquid hydrogen as a fuel in upper stage rockets allows significant increases in payload.

The initial Saturn will be capable of boosting 25,000 pounds into a 300-mile Earth orbit or sending 9,000 pounds on an interplanetary mission. Introduction of a new second stage consisting of a cluster of two of the new engines would increase the Saturn weight-lifting capacity by nearly 50 per cent; with a cluster of four new engines in a new second stage, the weight-lifting capacity would go up nearly 100 per cent.

The initial version of Saturn, consisting of a first stage of eight engines producing 1.5 million pounds thrust, a second stage of four 20,000-pound-thrust hydrogen engines and a third stage of two 20,000-pound-thrust-hydrogen engines, will come into use in 1963. The more advanced configurations will follow in the late 1960's.

END

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

Office of Public Information

June 3, 1960

INTERNATIONAL SATELLITE AND SPACE PROBE SUMMARY

The following space vehicles are in orbit as of this date:

NAME/COUNTRY	LAUNCH DATE	TRANSMITTING DATA
Explorer I (US)	Jan. 31, 1958	No
Vanguard I (US)	March 17, 1958	Yes
*Lunik I (USSR)	Jan. 2, 1959	No
Vanguard II (US)	Feb. 17, 1959	No
*Pioneer IV (US)	March 3, 1959	No
Explorer VI (US)	August 7, 1959	No
Vanguard III (US)	Sept. 18, 1959	No
Lunik III (USSR)	Oct. 4, 1959	No
Explorer VII (US)	Oct. 13, 1959	Yes
*Pioneer V (US)	March 11, 1960	Yes
Tiros I (US)	April 1, 1960	Yes
Transit IB (US)	April 13, 1960	Yes
Spacecraft (USSR)	May 15, 1960	Yes
Midas II (US)	May 24, 1960	Yes

*In solar orbit; others in earth orbit

CURRENT SUMMARY (June 3, 1960)

Earth Orbit:	US- 9 USSR- 2
Solar Orbit:	US- 2 USSR- 1
Transmitting:	US- 6 USSR- 1

COMPLETE SUMMARY (Launched to date)

Earth Orbit:	US- 19 USSR- 5
Solar Orbit:	US- 2 USSR- 1
Lunar Impact:	USSR- 1

REFRACTORY METALS IN THE EXPLORATION OF SPACE

Hugh L. Dryden, Deputy Administrator,
National Aeronautics and Space Administration

(Talk at dinner following Seminar on Inert-Fabrication Facility, St. Clair Country Club, Pittsburgh, Pa., June 8, 1960)

I welcome the opportunity to join in the proceedings associated with the technical presentation on the Inert-Fabrication Facility constructed by the Universal-Cyclops Company under sponsorship of the Navy Department. We in the NASA have found private industry able and eager to share the responsibility of advancing our accomplishments in the exploration of space. To an increasing extent the success of our ventures in space will depend on the cooperation of strong, competent, and creative industrial partners.

My coming is at least in part a recognition of the valuable counsel and advice of a highly qualified member of the Universal-Cyclops Company's staff who served for many years on the NACA Committee on Materials. In addition NASA wishes to congratulate the Company and the Navy for their foresight in anticipating the needs for better high-temperature materials.

This new facility is intended for development work in a class of materials which offers great promise for withstanding the aerodynamic heating of maneuverable space vehicles reentering the atmosphere at extreme speed. These materials are the reactive and refractory metals. The chief purpose of the IN-FAB room, to use the short-hand name of the facility, is to advance the technology of these metals. It is of this technology and of its many problems that I shall speak briefly.

I shall not, of course, talk about these problems in detail. In the first place, I fear that this audience is composed largely of materials specialists and experts in refractory metals whose detailed knowledge of the problems far exceeds my own.

In the second place, the refractory metals, with their many problems, have had more than their share of detailed attention in a multitude of papers, reports, meetings, seminars, and books in recent years. Even this week we have not only the seminar which we are attending here but also a symposium on columbium on Thursday and Friday of this week at Lake George.

I will therefore speak of the need for a dependable source of good quality refractory metals if we are to do the things in space that our country expects us to do. The need is connected with the severity of the expected thermal environment. I wish to emphasize that this need is here now. In fact, some unsatisfied needs are left over from years ago.

First, I would like to mention some well known areas where improvements in refractory metals would be reflected immediately--or almost immediately--in improvement in the performance of end-items or hardware. These improvements--using the word with a very broad meaning--would range from substantial increases in efficiency, to the removal of long-standing major roadblocks to hitherto unattainable levels of performance.

Thus the efficiency and performance of gas turbines is directly dependent on the maximum operating temperature. And, as I am sure you have been told many times, this maximum temperature is limited by the ability of our engine materials to withstand high temperatures.

It is for this reason that so much of the energy of the metallurgical industry--including that of the Universal-Cyclops Company--has been directed at the improvement of the high-temperature properties of the iron-, nickel-, and cobalt-based alloys.

But these efforts have long since reached the point of diminishing returns. Incremental improvements in these materials for parts for gas turbines can be looked for, of course, but for the major and important advances, the metallurgist must go to new alloy systems, based on the high-melting metals. This, of course, means the so-called refractory metals which, unfortunately, are also reactive metals.

As another example, the performance of the solid-fuel rocket is virtually at the mercy of refractory metal technology. The fuels we have today push our nozzle materials to their limits, and we now see our way to better fuels, which will be useless unless our nozzle materials can catch up with the higher temperatures resulting from the combustion of the new fuels.

As still another example the demands of nuclear-energy application may also be mentioned. Here too it is the ability of materials to withstand the very high temperatures needed in fuel elements, reactor core structures, and heat exchange devices that limits performance. This applies equally to nuclear rockets, nuclear ramjets, and nuclear turbine-type engines.

But I would like to concentrate your attention here, not on these powerplant aspects of the high-temperature materials problem--important and as critical as they are--but rather on the problems of aircraft and spacecraft structures in high speed travel through the atmosphere.

I do so because the IN-FAB facility is aimed chiefly at light gage sheet materials used principally in the airframe, missile, and spacecraft industry, whereas many engine parts such as nozzles or guide vanes use refractory metals in more massive sections made by other methods such as powder metallurgy.

We in NASA are primarily concerned with the application of sheet materials to hypersonic aircraft and spacecraft. Today we have already developed, or have very close to realization, booster systems of enormous power; we have also guidance and control systems of extreme precision. We will soon have the power, and the control of that power, that we need to orbit a manned vehicle with wings, or so shaped as to produce some lift, so that the time and place of landing can be controlled by a pilot.

Furthermore, we have every reason to expect that in the years not so very far ahead we will have boosters of much greater power that can launch such vehicles on even more distant journeys, to the moon, and in due course beyond to the other planets.

In fact the NASA has set for its next major goal after Project Mercury circumlunar journeys, first with instruments, then with men as pilots and passengers. At first, these vehicles will have to be aircraft as well as spacecraft . For on their outbound trip and on their return leg they will traverse earth's dense and oxygen-rich atmosphere.

In the more distant future, undoubtedly, we will have true spacecraft assembled in space and based from space platforms. The designers of such true spacecraft will be spared the aerodynamic heating problem we are discussing here, but we can be sure that they will encounter new and strange problems that are equally difficult and more so, for example, the provision of high temperature radiating surfaces to reject heat from the powerplant.

But our combined spacecraft-aircraft of the immediate future, since it will be earth-based, must be a true dual craft. It must live both in the hostile environment of space and in the atmosphere of its home planet.

On the return leg of a space trip, the so-called reentry maneuver, the heating will be both intense and of fairly long duration. This is our major problem in aerodynamic heating.

There is more than one way to solve the aerodynamic heating problem. The best solution will depend on the particular configuration and the details of its flight plan.

For example, the B-58, the X-15, the Mercury Capsule, the ICBM, the Dyna-Soar and the reentry of a winged vehicle from a hyperbolic path all have aerodynamic heating problems, the solutions to which will often differ as much as their configurations and their mission differ, one from the other.

But in general terms three main types of solution to aerodynamic heating have found practical application; viz., heat sinks, ablation, and radiation--or variations and combinations of these three. More limited use has been made of evaporation cooling by emission of fluid through a porous surface and of protecting blankets of cool or insulating gas emitted through slots or through a porous surface.

The heat sink principle is self-explanatory. Heat is simply absorbed in a large mass of material and carried along with the vehicle. For certain reentry maneuvers this method has turned out to be the most practicable. Its special areas of application are those involving a very intense heat pulse of short duration. Our first long-range missiles used this principle.

Ablation is a much more sophisticated solution. Essentially the heat is absorbed by a sacrificial material which leaves the vehicle.

This is the method we use to cool the Mercury capsule. Some ablating materials melt and are blown off but the more effective ones sublime directly from the solid to the gaseous phase, passing off as a cooler gas film which partially shields the body from the heated air passing over it.

The method of cooling by radiation, however, is the one of chief interest to us here, because it is through this method that the refractory metals can make their important contributions to solutions of the aerodynamic heating problem. Many of our own structures research people see this radiation method as the best solution to many important reentry problems. It is for this reason that they are so keenly interested in refractory metals and in what this IN-FAB room can do for refractory metals, especially in light gage.

The radiation method of cooling, in principle, is the essence of simplicity. We simply allow the structure to get as hot as it wants to get--in other words, to reach an equilibrium temperature. At first glance this may look more like a heating method than a cooling method. But this would be a very wrong impression, for two reasons.

First, virtually all of the heat transfer from the hot boundary layer to the vehicle is by convection--not radiation. This is true because the emissivity of the boundary layer gas is low.

Second, the emissivity of the vehicle surface can usually be made very high--near to 1.0. Consequently it can be a very good radiator and can radiate the heat out and away from the vehicle, provided the surface can operate at a sufficiently high temperature.

We have therefore a cooling method--perhaps better called a heat transfer method--that can take the intense heat from the vehicle surface and radiate it back out through the boundary layer into cold space.

One of the very attractive characteristics of this radiation system is the promise of light weight, especially for certain combinations of heating rate and duration. We do not have to carry along a mass of material to hold the heat as the heat sink method requires. Hopefully the vehicles could be used over and over again. But we do need a material that will serve as a very hot radiator.

We also will need good insulation to insulate the hot radiator from the interior of the vehicle. But this is a different problem which we will not concern ourselves with here.

Our radiator material must be able to withstand high temperatures. To just say "the hotter the better" is true, but it is an understatement--we should say, "the hotter the better to the fourth power." For as some of you remember from your freshman physics, the Stefan-Boltzmann law means that the radiant flux density varies as the fourth power of the absolute temperature.

Now the best nickel-cobalt type super-alloys we have or can hope to get will be limited to temperatures of about 2000°F. But radiators of refractory metals should be usable at 3000°F and up. If you take the trouble to raise these numbers to the fourth power you should first add about 460 to get degrees Rankine--you will see how very much more heat a molybdenum - 1/2 percent titanium radiator, for example, can dissipate than the best nickel or cobalt-alloy radiator. It would be about five times as good. And you will also understand why our structural research people, or the engineers who are trying to design a Dyna-Soar vehicle, are so very much interested in refractory metals--and also why they are interested in what this IN-FAB room might be able to do for the kind of refractory metals they need.

This Dyna-Soar vehicle of the Air Force which you have recently seen referred to in the public press is a vehicle of the general class I am discussing. It is a research vehicle for study of reentry problems and of sustained high-speed flight in the atmosphere. As envisaged now by the most promising preliminary design it will depend on the radiation principle for dissipation of the aerodynamic heat load. The demands it will put on materials are severe. Much of the body and wing surfaces will have to withstand temperatures of 3000° F.

This environment will demand one of the refractory metals. I am sure that you know that our metallurgical industry is not now ready with the kinds and amounts of refractory metal sheet that such an undertaking as Dyna-Soar requires.

The immediate and urgent need is for a reliable supply of large, thin sheet of refractory metals--molybdenum, columbium, perhaps even tungsten alloys--of good quality and uniformity. The aircraft - spacecraft industry needs this today, but it is not available from the metallurgical industry. The IN-FAB facility we hope will help solve some of the problems that prevent the filling of this need.

I would like to remind you however that an adequate supply of uniformly high-quality material is only a means to an end--not an end in itself. The payoff is the successful vehicle. And it is a very long and painful road from raw sheet material to a finished vehicle. When it becomes available our fabricating industries must take this new and strange material and learn how to form, machine, weld, braze, rivet and protect it. We can be sure that they will encounter as many new technology problems as they have processes.

This is a truth we learned from our experience with titanium. Much energy and money were put into the development of new alloys and of uniform high-quality titanium sheet, bars and extrusions. We also encouraged and stimulated production of raw materials--both ore and sponge. But we found, as I am sure that many persons connected with the titanium program expected and anticipated to the extent possible, that changing over from aluminum to titanium is not as simple as changing a specification indicated on a drawing. Forming, welding and machining procedures and tools must also be changed. And equally important and difficult, our shop engineers must learn new limitations and possibilities--our mechanics must acquire new skills. Partly as a result of these circumstances and partly because of the decrease in emphasis on development of supersonic aircraft, the use of titanium is lagging behind expectations. Today, much of our titanium producing capacity is idle, waiting for the consumer to solve his problem of how and where to use it.

A similar situation may develop in the case of the refractory metals, and we must do all we can to anticipate it.

We are dealing with the old problem of lead-time. Until the airframe industry has adequate supplies of refractory metals, it cannot go about the solution of its own problems. The airframe industry is looking to and waiting for the metallurgical industry for the necessary solution of the first problems before it can get on with what will be, I am sure, its own long sequence of problems. And the sooner it can get on with them the better.

The aircraft - spacecraft industry is a consumer of the product of the metallurgical industry. Consequently, the relationship between the two is fundamentally the producer-consumer, or vendor-customer relationship. Inherently there is an element of conflict of interest as well as a mutual dependency in this relationship. This conflict arises from the ever-increasing demands of the customer for newer and better products on the one hand and from the ever-increasing difficulties in satisfying such demands on the other.

This situation is not necessarily bad. In fact it is essential to progress for it provides our chief, or perhaps only, incentive to progress. Invention we are told is often born of necessity; supply is always stimulated by demand. During the first half of this century we have seen the aluminum industry and its technology progress steadily and orderly under this driving force, originating in the airframe industry. I am sure that many other examples of progress in the metallurgical industries under the stimulus and insistence of its customers immediately come to your minds.

During the last decade, however, there seems to have developed an increasing dissatisfaction, on the part of the consumers, with the speed with which the materials industries advance their technologies of the newer materials that are needed, especially for space activities. This dissatisfaction is often translated into a criticism of the materials industries, which I think is unjust. For it is clearly unreasonable and unrealistic to expect those companies which are the prime producers of such metals as, for example, columbium or beryllium, to undertake on their own the research and development that is required. The work is expensive; as in all research, success is uncertain. Furthermore, even assuming success, the size and continuity of the market are unreliable. It seems clear that the ultimate user must share the financial burden entailed in the development of these special-purpose limited-use materials. Often the country as a whole, as represented by the Department of Defense, the Atomic Energy Commission, or the NASA is this ultimate or sole user. After all we are all in the same boat, concerned with the national interest, and we share the responsibility for insuring progress.

These facts of life have been recognized in the past, of course, and will continue to be recognized. The development of our titanium industry; the present high activity in development of beryllium technology; the efforts of the Air Force to advance fabrication technology of columbium are a few examples. This IN-FAB room is but another instance of a cooperative effort of industry and government in dealing with the situation.

We do have now, in being, this special facility, specifically designed for processing the refractory metals. I am sure it was no small task to accomplish. It required imagination and courage; and I should add dollars too. We should all be grateful to those, both in Industry and in the Navy Department, whose hard work and perseverance made this facility a reality.

The metallurgical industry now has another powerful tool for shaping the reactive and refractory metals to the uses of man. I am sure that everyone connected with this unique and promising facility is impatient to get on with the job of finding ways to supply your restive customers with the kinds of metallurgical products they need.

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FOR RELEASE: Wednesday A.M.'s
June 8, 1960

RELEASE NO. 60-216

NASA TO FUND EXPERIMENTAL ION ENGINE

The National Aeronautics and Space Administration today selected Hughes Aircraft Co. to build an experimental ion engine.

Contract negotiations with the Culver City, Calif., company, one of 11 bidders in the contract competition, will begin immediately. It is estimated the year-long program to design, develop and laboratory-test the experimental engine will cost more than $500,000.

The engine development departs from conventional rocket engines in that there is no combustion. It works like this:

An alkalai metal atom (cesium) stream passes through a hot tungsten electrode which pulls an electron away from the cesium atom, creating what physicists call a postively charged ion. This ion stream is accelerated and focused by several more electrodes. Finally other electrons are mixed with the ion stream so that a neutrally-charged beam emerges from the engine. No nozzle is needed.

In the space of just a few inches, the ion stream develops a speed of more than 100,000 miles an hour. The cylindrical ion engine measures only about eight inches long and four inches in diameter.

This laboratory-type engine will be built to develop only about one hundredth of a pound of thrust. If test data prove the program feasible, later engines will be built to develop higher thrust levels.

Ultimately, scientists hope to use engines of this type to propel spacecraft on interplanetary missions. They would require a nuclear auxiliary power source such as SNAP-8 now under development.

Ion engines will not be used as primary launch engines because of their low thrust output. They would be built into spacecraft and turned on after the spacecraft achieves a predetermined trajectory.

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FOR RELEASE: TUESDAY A.M.
June 14, 1960

RELEASE NO. 60-212

NASA OUTLINES LAUNCH ORGANIZATION

The National Aeronautics and Space Administration today outlined the organization of its launch operations at U. S. missile ranges.

NASA launch operations will be coordinated by a Launch Operations Directorate (LOD). It will become operational on July 1, 1960, when the Development Operations Division of U. S. Army Ballistic Missile Agency formally transfers to NASA as the Marshall Space Flight Center. LOD director will be Dr. Kurt H. Debus, presently ABMA Missile Firing Laboratory director. Pending formal transfer, he immediately assumes interim supervision of NASA launch activities at the Atlantic Missile Range.

Dr. Debus heads one of the world's most experienced launching teams, having been responsible for the research and development launches of the Redstone, Jupiter, and Pershing missiles, including the first U. S. space satellite, Explorer I, as well as the first American payload to orbit the sun, Pioneer IV.

In addition to its NASA activities, the Launch Operation Directorate will take over the completion of ABMA Missile Firing Laboratory's current obligations to the U.S. Army Ordnance Missile Command for launching of Jupiter, Redstone, and Pershing missiles.

LOD will function as the central NASA group at AMR and Pacific Missile Range for all matters relating to over-all vehicle launch operations, and will act as the official NASA contact with range commanders and their staffs. Special limitations to this authority have been defined for the Delta and Mercury programs.

LOD will assume, on an expanded basis, the functions of the NASA Atlantic Missile Range Operations Office which initiated NASA's operations at AMR and established NASA launch operations procedures. Melvin N. Gough, AMROO director, having completed this assignment, will be transferred to NASA Headquarters Office of Space Flight Programs. He will serve as Flight Operations Coordinator for the Assistant Director of Space Flight Operations, coordinating NASA tracking requirements with other agencies and ranges.

As Launch Operations Director, Dr. Debus will report to the George C. Marshall Space Flight Center, Dr. Wernher von Braun, director. NASA Headquarters responsibility for launch activities, including the Marshall Center, is under the Office of Launch Vehicle Programs, Maj. Gen. Don R. Ostrander, director. His assistant director for launch operations is Samuel Snyder.

Also within the Launch Operation Directorate at the Atlantic Missile Range will be created an Office of Flight Missions (OFM) under John W. Rosenberry. OFM will coordinate range support requirements for the spacecraft activities of the various NASA field centers and submit their range requirements through the Launch Operations Director.

Deputy to Dr. Debus will be Dr. Hans Gruene. Assistant Directors will be Karl Sendler for Instrumentation, Albert Zeiler for Facilities, and Clarence C. Parker for Operations. The Chief of the Office of

Test Support will be Col. Asa M. Gibbs, who also will serve on the staff of the Commander, AMR, as Director of NASA Test Support at AMR.

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HOLD FOR RELEASE UNTIL DELIVERY - expected 12:30pm Friday, June 10, 1960

THE ROLE OF ENGINEERING IN SPACE EXPLORATION

Hugh L. Dryden, Deputy Administrator,
National Aeronautics and Space Administration

(Luncheon Talk at Annual Meeting of National Society of Professional Engineers, Boston, Mass., June 10, 1960)

May I say at the beginning how pleased I am to be with you today in response to your invitation extended through my good friend, Senator Saltonstall. My own professional life has been spent on the boundary line between science and engineering. Thus I have come to appreciate the contributions of engineers who apply the material resources and the energy sources of nature to the purposes of man.

There are few groups in our nation whose work is so much taken for granted and so little understood by the public. Engineers are only too rarely associated in the press with the great accomplishments of recent times. The development of the atomic bomb, nuclear power plants, and satellites are referred to as scientific achievements in a wholly unjustified perversion of the meaning of the word science. Many other writers seem to prefer the term technology to the perfectly good word, engineering. Among my daughter's textbooks I noted recently a History of Western Civilizations in which the words engineer and engineering do not appear at all.

I have often wondered why engineering of all the professions should be thus overlooked. At a luncheon during National Engineers Week a few months ago a group of us concluded that the characteristic feature of other professions lacking in engineering was the direct personal contact and the personal services rendered to individuals by the doctor, the lawyer, the minister, the educator. We find all around us the visible handiwork of the engineer in our bridges, highways, airplanes, ships, machines. Even in this building we recognize the electric lights overhead, the public address sytem, the air conditioning as produced by engineers, but whoever they are, they are anonymous. We do not recognize a professional relationship between one person and another. Engineers still have an immense task of public education. We must bring before the public the great engineers of our day as persons identified with their creative works and the contributions of these works to human welfare. Perhaps a well-known magazine which has just concluded a series on the great scientists of our day can be persuaded to turn their spotlight on the great engineers of our day.

Prior to the Industrial Revolution of the latter part of the eighteenth century the word engineering referred to the work of those men who constructed weapons of war, fortifications, bridges, and other works for military use. But as the Industrial Revolution progressed there arose a new class of engineers concerned with the construction of bridges, roads, canals, ports, etc., not associated with military activity. Not being soliders they were called civil engineers. Thus civil engineering is the mother of many of the present specialized branches.

Perhaps the first specialized branch to separate was mechanical engineering, then mining. To these have been added electrical, aeronautical, metallurgical, marine, chemical, illuminating, automotive, highway, structural, agricultural, sanitary, radio, electronics and perhaps others. The newest, not yet formally recognized, are the aero-space and astronautical engineers. The great variety and number of these prefatory adjectives have obscured the public image of engineering as a single profession.

On October 4, 1957 the world entered the Space Age, the beginning of the exploration of space by sending instruments to the place where measurements are to be made. In actuality the exploration of space began centuries ago when primitive man first observed the skies above and began the interpretation of what he saw. Human eyes were replaced by measuring instruments whose capabilities increased with advances in the science of physics. Astronomers by these methods have obtained an astonishing amount of knowledge about the size and extent of outer space, the number and character of celestial bodies, and details of their motion, chemical composition, and physical properties.

No exploration in human history has so stretched the imagination of man as the exploration of space. We have already sent instruments above the blanket of the atmosphere which is opaque to certain radiation frequencies and which protects the earth and man from the meteors, radiations, and charged particles from outer space. Soon man himself will travel in an earth satellite and begin the manned exploration of space.

New worlds to explore, new distances to travel. Pioneer V is now over 14 million miles from the earth still transmitting data on cosmic radiation, energies of charged particles, and magnetic field phenomena. The more than 100 hours of data have overturned well established theories about solar flare effects and have provided new information on the structure of the earth's magnetic field. But our solar system extends to 3000 million miles, seven years' journey at 50,000 miles per hour when we attain such a capability. Innumerable problems lie ahead for scientists and engineers of all descriptions to make possible the travel of man to such distances.

A characteristic feature of space exploration is the long lead time between a decision to undertake a specific flight mission and the flight itself. Thus the "weather" satellite Tiros launched successfully on April 1, 1960 used television instrumentation on which work was begun in 1957; the project was well under way when NASA was established in October 1958. The decision to launch Pioneer V was made shortly after that date; the successful launch was made on March 11, 1960. Both of these projects used available rockets. Programs requiring new launch vehicles demand lead times of several years. Thus a long-range plan covering many years and implemented with adequate resources is essential to progress in space exploration.

NASA has placed before the Congress a plan for the next ten years of space exploration. The weight of satellites which can be placed in orbit at an altitude of 300 miles is expected to increase during this period from the 100 pounds of the Juno II to more than 50,000 pounds. The increases take place as new vehicles, the Thor-Agena B, Atlas Agena B, Atlas Centaur, and Saturn with successively improved upper stages come to maturity. The level of activity contemplates about 30 major launchings per year.

The objectives are indicated in terms of the major target mission dates. In this calendar year we have successfully launched the meteorological satellite Tiros and we hope to have a successful launch of the passive communications satellite Echo. We expect to attain the suborbital flight of man in a ballistic path using the Redstone booster.

During calendar year 1961 we hope that an astronaut will travel around the earth in a satellite at a height of between 100 and 150 miles. A target date of 1963 is set for launching a stabilized astronomical observatory. The first launching in a program leading to manned flight around the moon and return to earth is planned in the 1965-67 time period. A near-earth space station is realizable in the same time period. Landing of man on the moon and return is estimated to occur early in the next decade.

The space flight missions of our national program of space exploration fall into three general categories. The first includes those missions intended primarily to produce scientific data with respect to the space environment , the sun, earth, and planets and the galaxy, using telemetry of information from unmanned vehicles. The second is composed of earth satellite missions for application to meteorological research and weather forecasting, long-distance wide-band communications, navigation, and similar tasks. The third relates to the travel of man himself in space, at first in a satellite orbit, later to the moon, and still later to the planets and outer reaches of the solar system.

The launchings of spacecraft to carry out the desired flight missions are the most visible and spectacular aspects of the space program. It is useful to consider the flight mission as being at the apex of a pyramid of effort which constitutes the major part of the program. Each mission rests on specific developments in three areas.

The first of these is the development of launch vehicles. Each mission requires a suitable launch vehicle. Our competitors in the USSR have made us painfully aware that we do not yet have launch vehicles suitable for many of the missions we would like to undertake. At present we are using launch vehicle systems based on the Thor and Jupiter IRBM's and there are coming into use systems based on the Atlas ICBM. The Saturn vehicle, based on a new superbooster with eight engines in a cluster, is being developed specifically for space applications. Its performance will determine the missions which can be flown in the period beyond 1965.

The second required supporting development for each mission is that of the spacecraft itself carrying the instrumentation and other apparatus required to accomplish the desired objectives. All spacecraft require communication with the ground and hence carry radio transmitters for telemetry and, if manned, for voice communication. All require a source of internal power, i.e., batteries, solar cells, nuclear reactor and turbo-electric generators, or similar equipment. Many require a working fluid and auxiliary jets or auxiliary rockets for control of attitude or spin or to modify the trajectory. The development of a large and complex spacecraft requires several years.

Finally each space flight mission must be supported by an extensive world-wide network of ground stations connected by communication lines to a central control and computation center. Equipment at these stations consists of optical, radio, or radar tracking apparatus, telemetry receivers, radio transmitters to send command signals, etc. For the tracking of spacecraft at distances of millions of miles and for wide-band telemetry of high data capacity, large steerable receiving antennas are required.

These three main supporting developments below the flight mission at the apex of our pyramid are in turn supported by a broad base of advanced technology, component development, and applied research in many fields of science and engineering.

Finally the space effort rests on the results of basic research in all branches of science, knowledge which is preprequisite to and contributes to a wide variety of engineering applications.

In this pyramid of scientific and engineering effort there will be found requirements for the services of almost every type of scientist and engineer to a greater or less degree. In the forefront, of course, are the aero-space and astronautical engineers but the development of the Saturn launching vehicle has also enlisted the cooperation of civil, mechanical, electrical, metallurgical, chemical, automotive, structural, radio, and electronics engineers. Much of their work relates to ground handling equipment, special automotive and barge equipment, checkout equipment, and all the other devices needed to support the design, construction, testing, launching, and data gathering.

Our technical progress is normally evolutionary in nature. The radically new advances usually result from the simultaneous maturing of developments in a number of fields. Some creative engineer notices that the integration of these developments makes possible the accomplishment of a task hitherto believed impossible. Consider the development of the intercontinental ballistic missile which opened the door to space exploration. The principles of rocket propulsion were known to Sir Isaac Newton. The demonstration of the major components of liquid fuel rockets was made by Goddard over 30 years ago. A large and bold engineering development applied to rockets in World War II by Von Braun and his associates in Germany brought forth a practical propulsion system for twelve-ton rocket vehicles. This development was essentially evolutionary in nature.

By contrast the intercontinental ballistic missile appeared full-blown from the combination of this development of large rocket engines, extrapolated six-fold in size, with newly maturing developments in structures (pressure stabilized fuel tanks, integrally reinforced skin, new welding methods, etc.), inertial guidance systems, light-weight nuclear warheads, and new methods of dealing with the problem of aerodynamic heating on reentry (new blunt aerodynamic shapes, heat sink designs, new ablating heat shields, etc.).

It is probable that there will be similar bold assemblies of developments in diverse fields to create new capabilities in space, for example, in the nuclear rocket propulsion of large spacecraft. But much of the space development will continue to be evolutionary. Research and engineering development of spacecraft will enable us to proceed from the non-lifting uncontrolled capsule to maneuverable lifting spacecraft. Research and engineering development of materials will let us progress to the use of better metal alloys and ceramics which melt only at very high temperatures. More complex and versatile communication and computer techniques will be developed. Other areas will show like advances. In each case the goal is to obtain devices to withstand still higher speeds, temperatures, or other adverse environmental conditions and simultaneously not only retain present performance and reliability but, if possible, improve them. Engineers who like challenging jobs will find that space exploration demands the utmost in developments at the frontiers of knowledge.

Space is thus a new frontier in many senses. I commend to your reading Ralph J. Cordiner's discussion of the new frontier in his lecture in the "Peacetime Uses of Space" series of the University of California. I will close with a few quotations from his lecture.

"At this stage, the new frontier does not look very promising to the profit-minded business man, or to the tax-minded citizen." ...

"Every new frontier presents the same problem of vision and risk. ... Lief Ericson discovered America 500 years before Columbus, but apparently the Vikings did not have the vision to see anything worthwhile on that vast, empty continent, and so history waited for another half millenium." ...

"When a new frontier is opened, the new territory always looks vast, empty, hostile, and unrewarding. It is always dangerous to go there, and almost impossible to live there in loneliness and peril. The technological capacities of the time are always taxed to the utmost in dealing with the new environment." ...

"It takes an immense effort of imagination for the citizens to see beyond these initial difficulties of opening a new frontier. No one would pretend to foresee all the economic, political, social, and cultural changes that will follow in the wake of the first exploratory shots in space, any more than the people in the days of Columbus could foresee the Twentieth Century world. But such an effort at prophetic imagination is what is required of us as citizens, so that we will not, like Leif Ericson, leave the making of the future to others."

The Age of Space Exploration is indeed a tremendous challenge to engineers as well as to citizens. To engineers it is a challenge to make the visions come true, "... to reduce design concepts to hardware with minimal cost and waste and the maximal useful results, ..." a challenge to continue to lead at the new frontier in contributions to the welfare of mankind.

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Speech of Harold B. Finger, June 15, 1960,
6th Annual Meeting of the American
Nuclear Society, Palmer House, Chicago.

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NUCLEAR PROPULSION FOR SPACE MISSIONS

Harold B. Finger
Chief, Nuclear Propulsion
Office of Launch Vehicle Programs
National Aeronautics and Space Administration

(Paper Presented at the Sixth Annual Meeting of the American Nuclear Society, Palmer House, Chicago, Illinois, June 15, 1960)

Ladies and Gentlemen of the American Nuclear Society and guests of the Society:

I appreciate very much the opportunity your invitation has provided for me to describe NASA's outlook on the application of nuclear energy to space exploration missions, and also to pass on to all of you, in various phases of the nuclear business, the exhilarating challenge offered to nuclear technology by our national space program requirements.

I suppose it is because I have spent twenty stimulating months working on space nuclear systems that I am so surprised that there have been only three papers presented during this session of the ANS directly concerned with space applications of nuclear energy. I believe that the American Nuclear Society and the scientific community participating in various nuclear programs must turn increasing attention to the space applications of nuclear systems to insure that the large performance potential of space nuclear systems is developed and exploited. I believe, further, that such increased attention to the space applications of nuclear energy is essential because it is apparent that technical developments in the space program will greatly enhance our technology in terrestrial applications of nuclear systems. In brief, I believe that you must be aware of our problems and of our developments so that you may be able to contribute to our program and so that you may be able to apply the technological progress of our work to your own programs.

Before discussing the NASA requirements for nuclear systems, it is important that I review the motivation and the objectives of the NASA space program so that the place of nuclear systems in that program will be more clear to you.

The NASA was activated in October of 1958 almost exactly one year after the Russian Sputnik startled and awakened the world, particularly the free world. Though NASA was born out of the Sputnik Scare as a means of overtaking Russian technology, it was decided very early in NASA that attempting to match Spectacular against Spectacular would completely fail to develop the technology that was required to give us the capability of performing any desired mission in space. It was determined that a broadly based scientific and technological program was required to insure that the United States came out first in the long term space competition with the Soviet Union and that the United States efforts contributed to man's understanding and utilization of space. The objective of our program is, in broad terms, to learn as much about the nature of the space environment as possible with confidence that these data, their application, and the understanding that results will find utility in our lives.

Although the Soviet Union has launched impressive and successful firsts; for example, the lunar impact and the photographing of the back side of the moon, the breadth and depth of our program are already being felt and appreciated throughout the world.

At approximately 17 million miles from the earth, Pioneer V has supplied us with very much information on the radiation levels, particle energies, and magnetic fields that it has encountered in its solar orbit. It has, in addition, given us data on long range communications requirements that will be of value in our follow-on missions. Tiros, the weather satellite, has sent back over 30,000 pictures of cloud cover that are serving as a new source of data input to our Weather Bureau to assist in determining improved methods of weather prediction as well as the factors affecting our weather. Aluminized balloons are scheduled to be placed in orbit to assist world-wide communications. Our first manned orbital flight is scheduled for the end of ~~this~~ next year. All told, the United States has placed 19 satellites into orbit around the earth and has had a total of 21 successful major launchings. This compares with 5 Sputniks and a total of 7 major launchings for the Soviet Union.

All of our missions have, thus far, been performed using launch vehicles based upon the IRBM and ICBM vehicles that were developed by the Department of Defense and second and third stages taken from the Vanguard rocket system. Our program has been limited by the payloads that could be launched with such "make do" vehicles. These vehicles did, however, give us the capability of initiating our program through the conduct of limited weight scientific and applied satellite experiments. Much new and significant data has been obtained in these experiments.

The Atlas-Centaur vehicle, which is scheduled for first flight in the middle of 1961, will use an Atlas first stage and a new hydrogen-oxygen second stage. It will give us the capability of placing a four ton payload into a low orbit around the Earth. With this vehicle, we will have a payload weight capability that matches or slightly exceeds the capability that has been demonstrated by the Russian space missions. In the scale of increasing payload, the Atlas-Centaur is probably the last of our vehicles that will utilize the ICBM first stage. It will be one of the limited number of vehicles that will find continued long term use in our program.

As you know, our Marshall Space Flight Center team in Huntsville, Alabama, under the direction of Wernher von Braun is developing the Saturn vehicle, which is the first vehicle specifically designed for space applications. In addition to various instrumented missions, Saturn will be used to carry a man around the moon and return him to Earth; a manned circumlunar mission. Saturn is made up of a first stage propelled by a cluster of eight 188,000 pound thrust engines using RP-LOX propellants and upper stages propelled by hydrogen-oxygen engines. The cluster of 8 engines which will propel the first stage has already been successfully fired for its full operating duration in a test stand at Huntsville. This million and a half pound thrust Saturn vehicle will have the capability of putting a 20 ton payload into a low Earth orbit using 3 stages or a 15 ton payload with two stages. Early versions of this vehicle should be available for use in 1964. Every effort is being made to insure a successful development of Saturn by 1964.

With this brief review of the objectives of our space program, some recent examples of its scope, and the vehicles we propose to use, I can start my discussion on the place of nuclear systems in our space program.

It is in the long range space program that nuclear systems will find broad application on the basis, not only of economic justification, but, more importantly, on the basis of accomplishing difficult missions that may not be possible by other means. In particular, the nuclear rocket, which has been receiving increasing attention during the past year, has strong potential in advanced lunar and interplanetary missions. The nuclear rocket uses a propulsion system in which hydrogen is heated to high temperature in a nuclear reactor and is then accelerated through a jet nozzle producing 2 to 3 times the specific impulse of our high energy chemical rocket engines. (The specific impulse tells us the amount of thrust that is produced by each pound per second of propellant that flows out the jet nozzle.) Because of the major role that will be played by the nuclear rocket in our space program, I propose to devote the major portion of my presentation to our nuclear rocket program, its goals and its potential.

In determining the place of the nuclear rocket in the advanced space program, it is important to consider the high payload space missions in which we are primarily interested. The missions that have been most publicized and that are being given very high priority in our program are the manned flight missions. Great and real concern has been expressed in Congress, in the press, and in various technical circles with the fact that manned landings on the moon are not scheduled in the NASA program until after 1970. We hear predictions that the Russians will land a man on the moon on every Soviet anniversary; and they seem to celebrate many events. None of these predictions seem to be soundly based. Our NASA program does intend manned lunar landings but realism puts them off to the 1970's. It must be recognized that we will not jeopardize the life of a man by sending him out on a mission of unknown hazards. The lack of knowledge of the space environment and of conditions on the moon, as well as the infantile state of technology of flight mechanics required to perform a landing mission, are just as responsible for the time schedule that has been set on a manned lunar landing as is the development of a reliable rocket system that can deliver the required payload. Our program is aimed at satisfying all of these requirements for lunar operations to permit earliest possible safe and reliable manned lunar landing missions. We recognize in this program that the design of a vehicle which will be capable of accomplishing manned lunar landing missions must soon be initiated.

If space rendezvous techniques are developed and orbital refueling becomes practical, then several Saturns could be used to launch a manned lunar expedition. Such an approach will be actively studied at Huntsville. Another approach which is being considered is a direct shot from the earth to the lunar surface and return to the earth. It is for such a direct manned lunar mission that a 9 to 15 million pound thrust all-chemical rocket system has been proposed. This rocket concept has been dignified by giving it a name, "NOVA". Unfortunately, to some people, the selection of a name is tantamount to making a vehicle available. I personally believe that detailed design analysis will show that smaller, less complicated lunar vehicles than the all-chemical NOVA are possible using combinations of chemical stages and nuclear upper stages. I suppose these chemical-nuclear vehicles deserve a name and "SUPER NOVA" seems appropriate. Many such vehicle concepts are being studied. Our analyses indicate, for example, that the combination of a cluster of two or three million and a half pound thrust chemical engines powering a first stage and various arrangements of chemical and nuclear upper stages will accomplish the same manned lunar landing mission as a 10 million pound thrust NOVA vehicle. In other words, a 3 million pound takeoff thrust chemical-nuclear vehicle can accomplish the same mission that requires 10 million pounds of takeoff thrust in an all-chemical vehicle. Such nuclear rocket applications require pre-orbital startup of the reactor system and the development and use of high power reactor systems.

Beyond the lunar landing mission, it is clear to all of us in this space business that, for interplanetary missions, nuclear rocket stages are so far superior to chemical systems in delivering high paylods that their development becomes a necessity if we are to have real freedom to travel at will in space. For such missions, I like to quote numbers that show that a 150,000 pound nuclear powered space ship can be started up in an earth orbit, orbit Mars, and return to the earth orbit with approximately

20,000 pounds or about 7 times as much payload as can be returned with an all-chemical system. For such round trip interplanetary missions, I don't believe that anyone doubts that nuclear propulsion will become the "work horse" of space.

We can design these chemical-nuclear rocket vehicles so as to include reactors having powers ranging from 1000 megawatts to 20,000 megawatts. In general, systems that are started in orbit may be comparatively low power systems, while the high powers are required for systems that are started before the vehicle has been established in an Earth orbit. Technical questions regarding the power density and the power level attainable must be answered before firm nuclear rocket vehicle designs can be formulated. In addition, the temperature level that can be attained, reactor life, system reliability, and controllability must be determined before major vehicle developments can be finalized. The nuclear rocket program being conducted jointly by the NASA and the AEC must recognize the large number of possible vehicle configurations that can be designed using nuclear stages and must be directed toward development of the technology that will permit a logical decision of the most desirable approach. Time's a'wasting. Vehicle decisions will soon have to be made. Our nuclear rocket program must, therefore, be a broad one that is well supported by competent scientists as well as by the funds to pay for their capability and for all of the equipment needed in such a development effort.

As you probably know, the nuclear rocket development program achieved a major milestone last summer when, on July 1st, the ROVER research reactor named the KIWI-A was operated by the Los Alamos

Scientific Laboratory at the AEC's Nevada Test Site thru a predetermined full power test sequence. The results of that test were extremely encouraging and, for those of us who were fortunate enough to have been present, it was a tense and emotionally stimulating experience. Within the next few months another test (the KIWI-A'), quite similar to last year's test, will be run in Nevada. This test will also use gaseous hydrogen as the propellant and will use water to cool the jet nozzle. Later reactor experiments will include operation with liquid hydrogen as the propellant, liquid hydrogen cooled nozzles, and liquid hydrogen pumping equipment similar to that required for actual nuclear rocket engine systems. The purpose of this phase of the program is the development of a reactor by the AEC which can then be incorporated into an engine by the NASA and can be test flown by the NASA.

We believe it is essential that flight testing of nuclear rocket propulsion systems be included as part of our nuclear rocket development program. The system to be flight tested need not necessarily be capable of performing useful space exploration missions. It must, however, supply technical data on the engine and the vehicle that are applicable to systems which will be used in our space program. Our present program plans call for the flight testing of a nuclear rocket stage as an orbital start stage by 1965. This nuclear stage will use one of the reactors being developed by the Los Alamos Scientific Laboratory and will be boosted into orbit by the two-stage Saturn vehicle.

Other methods of flight testing have been proposed. Among these are ground launched test shots and limited range flights over water with a nuclear second stage. Neither of these systems has been ruled out of our program. They are being evaluated before the flight test system and program are finalized.

One of the major advantages of the orbital start test stage on Saturn lies in the fact that this test stage appears to have the potential for development to operational status. It could then provide a Saturn vehicle configuration made up of a two-stage Saturn with a nuclear third stage which could deliver approximately twice the payload of the all-chemical Saturn for an escape mission. It is, however, my attitude that even if such a configuration gave no payload increase, such a three-stage chemical-nuclear Saturn should become an operational vehicle in order to supply us with operational experience on nuclear stages so as to develop necessary reliability and a firm feeling of confidence in its capability and, also, confidence that none of the operating problems have been overlooked. Such a feeling of confidence is essential if we are to commit our stable of vehicles beyond Saturn to nuclear systems.

To summarize the status and plans of the NASA-AEC nuclear rocket program, the following points can be made:

1. Present emphasis is on reactor research and development leading to a reactor which will be used for flight tests of a nuclear stage.
2. Flight tests of a nuclear stage are planned to start in 1965.
3. Operational use of a nuclear stage on the Saturn vehicle to develop confidence in the solution of nuclear rocket operating problems appears desirable.

4. Application of nuclear rockets as work horse vehicles for advanced missions requiring high energy to deliver extremely large payloads over long distances is anticipated.

In addition to the nuclear rocket, the use of nuclear energy sources to produce electrical power should find broad application in the space program. Our electrical power requirements vary from small fractional watt levels for auxiliary power requirements of certain of our space sciences experiments to the megawatts of power that will be required if and when electrical propulsion is considered feasible. Thus far, none of our space missions have used nuclear electric power generating equipment even though the Atomic Energy Commission's SNAP program has gone a long way toward developing operational radioisotope powered systems and is now deeply engaged in development of reactor powered systems. We have been able to accomplish our missions using batteries or solar cells. However, for long life lunar landing missions where a fourteen-day night makes harsh demands on a storage battery system coupled with silicon solar cells, it appears that a nuclear powered system has marked performance advantages in terms of life and weight. Also for Venus missions where the heavy atmosphere precludes the use of solar energy, battery or chemical systems appear to be excessively heavy to provide the long life transmission power that will be desired once we have placed an operating payload on the planet's surface. For such missions, we would like to use nuclear auxiliary power systems.

In addition to the auxiliary power requirements, electrical power will be required for the electrical propulsion devices that are being studied and developed on almost every electronics work bench in the country. In fact, I am convinced that the feasibility of electrical propulsion depends upon the development of sufficiently light weight electric power generating systems. It appears that the development of high power, light weight systems (as low as 10 pounds per electrical kilowatt of electrical power is desired in the neighborhood of 1 megawatt) will require the use of nuclear reactor systems operating with liquid metals and metal vapors at temperatures approaching 2000°F. Those of you who have worked with liquid metal cooled reactor systems know what a difficult problem we face. Not only is such a temperature difficult to handle for short periods, but the added requirement that these space systems have unattended operating life in excess of a year compounds the difficulties by several orders of magnitude. It is apparent that all possible experience must be brought to bear on these problems.

I should point out that the picture is not quite as dark as it may seem. There is much that can be done within current state-of-art. For example, the NASA is developing, with the Atomic Energy Commission, the SNAP-8 system which will be the first system that will have the capability of supplying electrical power for early electrical propulsion systems as well as for long range communications. The SNAP-8 system will deliver 30 electrical kilowatts and with two of its mercury turbogenerator conversion systems operating in parallel off the single reactor, will develop 60 electrical kilowatts. In its 60 kilowatt version, the SNAP-8 has the capability of delivering a 6000 pound payload to Mars with a spacecraft having an orbital weight of 9000 pounds. Part or all of the SNAP-8 electrical power can then be converted to supplying the communications power that may be required for television transmission to earth. It is our hope that a SNAP-8 powered electric propulsion system may be flight tested in 1964.

Our program for development of nuclear systems for space applications is, and must be, an aggressive one. We intend to conduct flight testing of several nuclear systems within the next five years. We may also use small nuclear systems for generation of electrical power in useful missions during that period. Within this decade, we clearly look to the useful application of nuclear rockets and nuclear reactor electric power generating systems. Many of the technical problems involved in these developments are formidable and must be solved. Since our space program requires that we develop the capability of performing any desired mission, so our nuclear systems program must also be a broadly based research and development program that will permit us to apply nuclear energy to all of those missions for which it appears to be well suited.

In addition to the technical problems that must be solved, the application of nuclear systems for space application requires that we satisfy all of the necessary requirements to insure the safety of these systems. Safe operation is obviously a requirement of all of our space systems. However, in view of the world wide concern over radiological release, it is mandatory that we insure that no incident involving nuclear radiation occur. The problem is significantly different from the one involving ground power stations where containment can be provided and insured. Safety requirements must be defined for the space systems as they have been for ground systems. We must then determine whether or not we can satisfy all of the necessary safety requirements. A comprehensive analytical and experimental program will obviously have to be conducted to insure that the necessary safety requirements are satisfied in our space systems.

In summary, it should be recognized that the space nuclear systems are in somewhat of a unique position in that there are so many useful and necessary missions that they can perform efficiently. The performance potential of nuclear systems in our space program is so great that the research and development program on these systems must be aggressively pursued on a very broad base. We must insure that the technology is developed so that we may accomplish any of the many space missions for which nuclear systems appear to be well suited. In addition, the safety requirements for nuclear systems applied to the space program must be defined and experiments must be run to insure that these requirements are satisfied in our program. The technological developments and advances that result in our program will be great and should bring major benefits to all nuclear technology. They will produce a major benefit to our nation in its international position of leadership.

NEWS RELEASE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
1520 H STREET, NORTHWEST · WASHINGTON 25, D. C.
TELEPHONES: DUDLEY 2-6325 · EXECUTIVE 3-3260

FOR RELEASE: Monday, June 20, 1960

NASA Release No. 60-219

THOMAS L. K. SMULL APPOINTED DIRECTOR, OFFICE OF RESEARCH GRANTS AND CONTRACTS

Thomas L. K. Smull has been appointed Director of NASA's Office of Research Grants and Contracts. He succeeds Lloyd A. Wood who has been named Scientist for Advanced Technology in the Office of Program Planning and Evaluation.

The Office of Research Grants and Contracts is responsible, as the central point in NASA, for coordinating the programming and use of funds for basic research, for initiating and coordinating all business management relationships with nonprofit scientific and educational institutions, and for maintaining current information on the status of all basic research projects.

The Smull appointment coincides with a change in the organization of NASA research grants and contracts to nonprofit institutions. His office, formerly a part of the Office of Advanced Research Programs, has been transferred to the Office of Business Administration in order to serve research needs of all NASA's major programs -- advanced research, life sciences, space flight, and launch vehicles.

Because of the expansion of NASA-sponsored basic research, arrangements are also being made to assign (after initial coordination by Smull's office) technical monitoring and business administration of certain grants and contracts to the NASA field center where most of the interested technical staff is located.

Smull, 43, is a native of Ada, Ohio. Formerly assistant chief of the grants and contracts office, he joined the National Advisory Committee for Aeronautics, NASA's predecessor, in 1939.

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THE EXPLORATION OF SPACE

Hugh L. Dryden
Deputy Administrator
National Aeronautics and Space Administration

(Presented at 23rd National Applied Mechanics Conference,
Pennsylvania State University, University Park, Pa.,
June 21, 1960)

The opportunity of meeting with you tonight gives me a great deal of pleasure. There are many old friends in this audience and their presence and this occasion bring back prized memories of the time when I was active in the work of the Applied Mechanics Division. At that time my major interests were in research in basic aspects of fluid mechanics, on boundary layer and turbulence problems. Now the pressures of time and environment have brought many responsibilities of administration in the exploration of space and great restrictions on my freedom to attend scientific meetings. I welcome the privilege of spending this hour with you to discuss current activities in the exploration of space and their significance.

We date the Age of Space Exploration from October 4, 1957 when man sent into space the first artificial satellite of the earth. In reality the exploration of space began centuries ago with those forerunners of present-day astronomers who first observed the skies above and began the interpretation of their observations. The apparent regular motion formed the basis of the first clocks and almanacs. The sun, moon, and planets became first objects of worship, then objects of study. Human eyes were replaced by measuring instruments, and advances in the science of physics led to methods of inferring the chemical composition and physical properties of the celestial bodies from the light which penetrated our atmosphere. The knowledge of outer space and of the sun, moon, planets, and of the universe gained by astronomers through the centuries is indeed remarkable.

But now we can send our instruments for direct measurements and the way is opened for man himself to venture into nearby space, and in time to explore the solar system. The Congress of the United States has declared "that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind," and has established a new governmental agency, the National Aeronautics and Space Administration, to implement that policy. There is about to be appropriated the sum of approximately $900 million to carry on the exploration of space during the year beginning July 1, 1960. I would like to report to you very briefly the responsibilities and plans of NASA.

The mission of NASA is most clearly stated in a bill amending the National Aeronautics and Space Act of 1958 which has passed the House of Representatives and is before the Senate for action. This bill states that:

"Sec. 202.(a) The Administration, in order to carry out the purpose of this Act, shall--

"(1) formulate specific national objectives in space and, in the light of such objectives, develop a comprehensive program for the exploration, investigation, and utilization of space for peaceful purposes;

"(2) conduct research into problems of flight within and outside the earth's atmosphere with a view to their practical solution, including research in the field of aeronautics necessary to the continued advancement of both civilian and military aviation;

"(3) conduct such activities as may be required for the exploration, scientific investigation, and utilization of space for peaceful purposes, and develop space vehicles for use in such activities;

"(4) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and to conduct or arrange for the conduct of such measurements and observations; and

"(5) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

In recent weeks under the stimulation of the approaching selection of presidential candidates we have seen much attention given in the daily press, in magazines, at cocktail parties, and around the dinner table to questions of national purpose and the role of leadership in a democracy. Just two days ago I sat in a group debating whether a democracy can ever take the initiative in any matter. Are the processes of decision in a democracy as slow, as contrasted with decision in a dictatorship, that we can only respond with time lag to the initiative of others? In the age of space exploration we need creative effort and leadership in many fields. Our group concluded that, no matter what the governmental system, creative contribution, initiative, and leadership came only from individuals, not from governments. A democracy can be creative, to the extent that it produces and follows creative leaders.

The broad horizons of space opening before us have emphasized the need for leadership in almost every aspect of life, to bring the horizons of vision and accomplishment in those areas to be commensurate with an age of space exploration. Not only in technology do we find this need but also in education, government, industry, law, ethics, and religion. Of concern to us tonight are the implications for engineering and engineers.

First we find increased pressures to accelerate the tempo of changes in engineering education and practice which began during the last war. You will recall that there then arose areas of development in fields such as radar and nuclear energy, which were inherently engineering in character. However, there were few engineers then available who knew enough about the scientific advances to exploit them. In addition, engineering developments in hitherto unexplored fields were found to be necessary. Science and engineering became intermingled in a new breed of engineers, some being physicists and chemists who had absorbed engineering knowledge, some engineers of many branches who became knowledgeable of nuclear physics and chemistry. The best qualification that this new nuclear engineer could possess was a thorough knowledge of the basic principles of mathematics, physics, and chemistry. Similar experiences were encountered in aeronautical and guided missile engineering.

All of you are familiar with individual leaders throughout the country who are taking the initiative in this matter of engineering education. An.engineer who understands the basic principles of heat transfer can apply them to new situations in new technologies, to the cooling of a radar transmitter tube, a reactor fuel element, or even a satellite and its equipment in the space environment. Less specialization and a greater integration of basic scientific principles underlying all engineering application are essential to survival in a rapidly changing science and technology.

In the mechanical engineering profession this emphasis toward the basic principles has been characteristic of the Applied Mechanics Division. Nevertheless I believe that we too need creative leadership in a reassessment of the scope and center of gravity of our activities in the light of the advancing frontiers of science and technology. Less specialization, expanded scope, and a move toward basic science seem to me to be necessary. This is not the place to attempt an exhaustive review of the role of applied mechanics in space technology. Because of your past work the general behavior of thin-walled structures under static loading is fairly well understood, although space applications move to ranges of parameters beyond those characteristic of other technologies and to new materials. The critical loadings and properties in space technology today relate to the dynamic behavior of such thin walled structures under wind shear excitation or acoustic excitation from rocket noise, complicated by sloshing fuel, air turbulence, and control interactions. High and low temperatures from melting or sublimation temperatures of ablation heat shields to liquid hydrogen temperatures must be considered. Flutter, creep, thermal expansion become major problems. Radiation cooling is the principal method available in outer space, requiring, for efficiency, high surface temperatures.

In examining research needs in the material field for space applications, we find it necessary not only to consider density, strength, ductibility, stiffness, and fatigue, but also creep, thermal expansion, thermal conductivity, specific heat, thermal shock resistance, emissivity, ignitability, ablation, radiation resistance, resistance to meteorite impact, reaction to ionized gas, and vaporization.

As I look over the program of this conference, I find few papers dealing with problems pertinent to space applications, not really surprising since serious interest in space exploration is less than three years old and it takes time to do research and report its results. But take note for the future. Move your interest closer to solid state physics and mechanics, surface chemistry, radiative heat transfer, motion of plasmas as well as viscous fluids. Expand your scope of interest, or some other group will assume leadership. The space age requires that you take the initiative.

Space is the new frontier in many senses and has all the characteristics of a frontier, the difficulty of justifying the resources needed to explore it. Is the urge of man to explore and to know a sufficient reason to explore space at a cost of a billion dollars a year? Certainly it is one of the reasons new knowledge of the universe has in the past always been found to be a gold mine whose output had continuing repercussions on man's life on earth and on his intellectual and spiritual horizons. These later effects were at the time completely unforeseeable.

The exploration of space promises knowledge which can be exploited almost immediately for the economic and social benefit of man. The rich treasure returned is as real as gold from the new world in the seventeenth century, or spices from India, or furs from the far North. We see the value of the development of meteorological and communications satellites and of the advanced technology required for more and more difficult space missions. But probably the most important returns are those we do not and can not now foresee.

I commend to your reading Ralph J. Cordiner's discussion of the new frontier in his lecture in the "Peacetime Uses of Space" series of the University of California. I will close with a few quotations from his lecture.

"At this stage, the new frontier does not look very promising to the profit-minded business man, or to the tax-minded citizen."...

"Every new frontier presents the same problem of vision and risk. ... Lief Ericson discovered America 500 years before Columbus, but apparently the Vikings did not have the vision to see anything worthwhile on that vast, empty continent, and so history waited for another half millenium."...

"When a new frontier is opened, the new territory always looks vast, empty, hostile, and unrewarding. It is always dangerous to go there, and almost impossible to live there in loneliness and peril. The technological capacities of the time are always taxed to the utmost in dealing with the new environment." ...

"It takes an immense effort of imagination for the citizens to see beyond these initial difficulties of opening a new frontier. No one would pretend to foresee all the economic, political, social, and cultural changes that will follow in the wake of the first exploratory shots in space, any more than the people in the days of Columbus could foresee the Twentieth Century world. But such an effort at prophetic imagination is what is required of us as citizens, so that we will not, like Leif Ericson, leave the making of the future to others."

The Age of Space Exploration is indeed a tremendous challenge to engineers as well as to citizens. To engineers it is a challenge to make the visions come true, "...to reduce design concepts to hardware with minimal cost and waste and the maximal useful results, ..." a challenge to continue to lead at the new frontier in contributions to the welfare of mankind.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

June 23, 1960

NOTE TO EDITORS:

The attached address by Major General Don R. Ostrander, USAF, Director of NASA's Launch Vehicle programs, is being given at Western Michigan University on June 23, 1960. It is one of the most comprehensive and yet concise presentations of the U. S. Space Exploration program that I have been privileged to see. I thought that you would wish to have it for background and reference use.

Walter T. Bonney

Walter T. Bonney, Director
Office of Public Information

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

HOLD FOR RELEASE UNTIL DELIVERY
EXPECTED 2:00 P.M., CST
JUNE 23, 1960

THE U. S. SPACE EXPLORATION PROGRAM

Address by Maj. Gen. Don R. Ostrander, USAF, Director, Launch Vehicle Programs, National Aeronautics and Space Administration, at Western Michigan University, Kalamazoo, Michigan, on June 23, 1960.

I thought that today I would try to tell you something about the organization for which I work - the NASA - a little bit about the program we are currently conducting and something of our plans for the future, and describe for you how we go about managing the program.

We in the NASA are, after all, spending something in the order of a billion dollars a year of the taxpayers money at present, with the prospect of it going to somewhere around a billion and a half to two billion dollars in the future, so I feel that you, as either present or potential taxpayers, are entitled to know what we are doing and what you can expect for your money.

First of all, something about our organization.

The organizational center of our space program is our Headquarters, located in Washington, D. C. The organization is headed by Dr. T. Keith Glennan and his Deputy is Dr. Hugh L. Dryden.

Before coming to NASA, Dr. Glennan was President of the Case Institute of Technology in Cleveland, Ohio, and is currently on leave from that institution. During the War he was Director of the Navy's Underwater Sound Laboratories at New London, Connecticut, and he has also served since the War as a member of the Atomic Energy Commission.

Dr. Dryden, prior to his appointment as Deputy Administrator, was Director of the National Advisory Committee for Aeronautics, our predecessor organization. Both Dr. Glennan and Dr. Dryden have been with NASA since its formation in October of 1958.

Under the Administrator are five major staff offices, or Directorates, that plan, integrate and manage our total research and development program. Taking these five Headquarters activities in turn, we have first of all an Office of Business Administration which supervises the normal functions of personnel, procurement, supply, transportation, etc., in support of our technical activities.

Next, in the area of basic research, we have the Office of Advanced Research Programs, where emphasis is placed on the application of basic sciences to aeronautical and astronautical problems, in order to insure our continuing advancement in the state-of-the-art in these areas, and to provide a sound scientific background and basis for our development programs.

Closely allied to the Office of Advanced Research Programs, but somewhat more specialized in its purpose, is the Office of Life Science Programs. It is in this area that we relate our research findings to what, certainly, is one of the most exciting facets of space exploration and, at the same time, the one that presents some of the greatest problem areas. I refer, of course, to our program to place man into space. The effects of acceleration, deceleration, weightlessness, and cosmic radiation on the human body are just a few of the problems that must be solved in this area. This Office is also organizing our investigations as to the possibility of life-forms on other planets.

The translation of this research work into more specific and material things is divided into two organizational areas of development. One is my own organization, the Office of Launch Vehicle Programs, which is responsible for developing the rocket boosters and supervising their launch operations, in order to place a payload into orbit or to probe outer space. The other is the Office of Space Flight Programs which provides the spacecraft or payload required to obtain the information or to perform the function that we desire on a specific space flight mission.

Relatively speaking, the NASA Headquarters is a fairly small organization, with bout 600 people, and is staffed primarily to plan and supervise an integrated space program. The bulk of our actual day-to-day scientific and development activity, however, is conducted by our field establishments, consisting of four research centers, three space flight development centers, and three rocket launching activities - one at Cape Canaveral in Florida, one at the Pacific Missile Range on the West Coast, and the third at Wallops Island, Virginia.

A field establishment of this size and diversity did not, of course, materialize overnight nor during the short time that NASA has been in existence. The four research activities were absorbed with other functions of the National Advisory Committee for Aeronautics when NASA was created in 1958. Incidentally, in this area we are still responsible for the aeronautical research activities formerly conducted by the NACA, and are active in matters dealing with aviation, but there has of course been an inevitable shift of emphasis from the problems of conventional aircraft to the more demanding problems of space exploration.

In addition to the nucleus of the NACA staff and facilities, the NASA absorbed from the Naval Research Laboratory the group which conducted the Vanguard satellite program in connection with the International Geophysical Year, and from the Army the Jet Propulsion Laboratory of the California Institute of Technology and Dr. Wernher von Braun's group at Redstone Arsenal. So that of our total staff of around 16,000 people, actually only a relatively small number represent new Government employees.

Taking first the area of basic research, I would like now to describe for you the scope and responsibilities of these field activities. The Langley Research enter, located at Hampton, Virginia, is the oldest of the former NACA laboratories and the largest of our research activities. Here a staff of some 3200 people is occupied with such basic problems as the physical limitations of materials and structures, the physics and aerodynamics of re-entry vehicles, continuing work in aircraft aerodynamics, and fundamental research in stability and control.

At Cleveland, Ohio, we have the Lewis Research Center, where a staff of 2700 is concerned with investigations relating to all aspects of aircraft and rocket propulsion. Research programs in this area are now active on chemical rockets, with emphasis largely on new and advanced high energy propellants, on nuclear rockets, and on electrical propulsion devices.

Much smaller in size than the other activities, but unique and specialized in its own right, is the Flight Research Center at Edwards Air Force Base, California. It is located on the edge of Rogers Dry Lake, along with the Air Force Flight Test Center, and it takes advantage of the 75 square mile flat surface of the lake as an ideal testing ground for research aircraft. A current staff of 416 people is engaged almost full time on flight testing the X-15 research aircraft. Although this project comes under the general heading of aviation, it actually represents a first, but very significant, step toward ultimately placing a man into outer space, since this plane is designed for a maximum speed of over six times the speed of sound, and a maximum altitude of 250,000 feet.

Also located in California is the Ames Research Center at the Moffett Naval Air Station in the Santa Clara Valley. This group of about 1400 people conducts research in the environmental physics of space operations, including simulation techniques, gas dynamic research at extreme speeds, and automatic stabilization and guidance and control of space vehicles. In the field of aviation they are also engaged in an active program in connection with vertical take-off and landing aircraft.

Whereas these Research Centers generally do their work in-house, in their own laboratories, and are staffed with relatively small groups of highly trained scientists representing a great diversity of skills and knowledges, on the development side we conduct a much greater proportion of our work by contract, both with industry and with universities and other non-profit research organizations. Here we require in general larger numbers of people and a greater investment in facilities and equipment because of the sheer size of the program.

As I mentioned earlier, our development activity is divided into two major material areas: Launch Vehicles and Space Craft. Supporting the spacecraft development program are two centers, each concerned with a specific area of space operations. Responsibility for development of earth orbiting craft or satellites is vested in the Goddard Space Flight Center which is the only new organization we have formed. The staff of this Center is presently housed at various temporary locations around the Washington area and is scheduled to move this summer to a new permanent facility under construction at Beltsville, Maryland, just north of Washington. The staff will consist of 2,000 people, with the original Vanguard satellite team as a nucleus. The major program elements of this Center are scientific satellites, sounding rockets, the manned space program, and the application of space vehicles to useful purposes, including communications and meteorology.

The other major area of spacecraft development is assigned to the Jet Propulsion Laboratory at Pasadena, California. This laboratory is operated for

NASA by the California Institute of Technology, and is concerned with the exploration of deep space, including unmanned lunar and interplanetary flights.

Development of our launch vehicles is concentrated at the George C. Marshall Space Flight Center at Huntsville, Alabama, under the leadership of Dr. von Braun. As I mentioned, this operation is being transferred to us from the Army Ballistic Missile Agency and will be officially established under NASA on 1 July. A total staff of 5500 people is now planned for this Center.

In addition to the development of vehicles, the group under Dr. von Braun will also be responsible for the associated vehicle launch operations. For this function, missile firing operations have been established at Cape Canaveral, Florida, under Dr. Kurt Debus, who has launched all of Dr. von Braun's missiles for him since the early days at Peenemunde in Germany. We will also establish a group under Dr. Debus at the Pacific Missile Range on the West Coast. The operation on the west coast will be smaller in size and will be used principally for spacecraft requiring a Polar orbit, by which I mean, of course, an orbit going essentially north and south, over the two Poles, rather than east and west around the earth. At Wallops Island, off the Virginia coast, we have another small launching organization which conducts numerous launchings of smaller sounding rockets.

So much for our organization. Now I would like to tell you a little something about our program.

An organization such as I have just described is, in essence, a collection of skills; but these skills have little meaning, of course, unless they are properly organized and directed to meet specific missions and objectives. In general, the objectives for our civilian space exploration program can be grouped into three major categories.

The first category is our Space Sciences Program, which is fundamental to all of our effort in that it provides the basic scientific knowledge that is essential to the development of specific uses of space environment. In this area, instrumented satellites and space probes measure and record the scientific properties of the atmosphere, ionosphere, and both nearby and outer space, and as time goes on will provide us with basic information on the origin, composition, and environment of the moon and the planets. In an overall sense, we have to expand our fundamental knowledge of space and its characteristics and concurrently develop the material and techniques that will allow us to probe even further into space. You might well ask whether this is not just a vicious cycle, wherein each new bit of knowledge we gain simply creates an insatiable desire for more knowledge and with it an even greater demand for new developments. The answer, quite obviously, is yes. In fact, this is our very purpose in being. However, I think the important point is that this process is not performed in a pure vacuum of intellectual curiosity. Both the elements of scientific exploration and the development of practical applications have to be integrated and balanced in relation to our long range objectives, and no one area can be carried on without the support of the other.

The second category in our program is this practical application of satellites to useful ends to benefit our day-to-day pattern of living. In this area we can already foresee tangible and very significant advances in the fields of communications, meteorology and navigation through the use of satellites. I am sure you are familiar with the recent launch of our meteorological satellite, Tiros I, which will be followed by its successors, Tiros II and Nimbus, each a little more complex and sophisticated, and contributing, we hope, to major advancements in weather forecasting. No less significant is our Project Echo, which will place metallic-coated, plastic balloons into orbit to be used as passive reflectors off of which we can bounce radio signals to improve our long range communications. Our first launch in this series, in May, was unsuccessful, but we have another scheduled later in the summer.

The third category is concerned with travel of man into space with anticipated trips to the moon and, ultimately, travel to the other planets. As you know, we are already deeply engaged in Project Mercury, as this program is called, and in other scientific investigations that we hope ultimately will lead to space travel. As to the immediate benefits, there is little question that a successful launching of man into space would do a great deal to enhance our national prestige. However, this is not the objective of Project Mercury. The goal is to determine the degree to which man can tolerate the environmental conditions of space flight and still perform operations sufficiently important to warrant his participation in future space explorations, with all the additional complexity his presence imposes.

During the current year, our efforts are directed primarily toward major tests of new vehicles, orbital experiments in meteorology and communications, and, on the more dramatic side, the first sub-orbital flight of a manned space vehicle under Project Mercury. By sub-orbital I mean, of course, that one of our astronauts will ride a capsule on a Redstone missile in a ballistic up-and-down trajectory much like the flight of a ballistic missile.

Assuming continued success in the schedule of tests for Mercury, the first orbital flight will occur in 1961. We also plan the launching of an advanced lunar impact vehicle during the latter part of '61 or the early part of '62.

From this point on, our major milestones include a comprehensive program of un-manned exploration of the moon and nearby planets leading toward manned circum-lunar flights - flights around the moon and return - and ultimately a landing of man on the moon during the early 1970's.

This undertaking is ambitious by nearly any standard, but what I think is perhaps even more significant is the unique character of the basic mission and responsibilities of our organization. Under NASA we have for the first time, I believe, a Government agency that is devoted solely to research and development. Although both military and other civilian agencies are engaged in research, their efforts are undertaken only to the extent they support the agency's prinicpal mission. In the case of NASA, our sole and only mission is the research and development itself, with the end product being turned over to others for specific application.

This gives us some unique advantages, in that we are not tied to immediate objectives or specific end items - we can project our program beyond immediate and practical considerations and seek out and create opportunities rather than to wait and let them evolve through normal processes. On the other hand, it presents us with some very real problems and difficult decisions in that we have to exercise extremely selective judgment in choosing from a virtually unlimited field of potential scientific experiments, each with its very sincere and enthusiastic proponents amongst the scientific community.

Now I would like to tell a little about the program in my own area - the area of development and operation of rocket launch vehicles - something of the problems involved, how we manage the program, and what we are doing.

When man first entertained the idea of flying - even a few feet above the ground - he was faced with the very practical consideration of gravity. Today, in the space age, this problem is no less acute. Unfortunately, in this area, however, there are no shortcuts. We have to use brute strength to literally and figuratively blast our way through the earth's gravitational pull. My job is to overcome this gravitational force and to place a payload into space, at the proper place and time and with the accuracy required. In this sense I provide what you might consider as a hauling service for other elements of the space program. Granted that these are pretty complex and expensive trucks, but that's really what it boils down to.

It is in this area, as you know, that our space program has been subjected to its most severe criticism. It is no secret that in the development of high thrust vehicles the Russians enjoy a substantial lead, nor is there anything to be gained by trying to rationalize the various factors that have placed us in this position. We have to simply accept it as a fact and proceed to close the gap as quickly as possible.

On this latter point, however, I would like to inject one thought. The question has been repeatedly asked and heatedly argued in recent months as to whether or not we are engaged in a space race with the Russians. I guess it is a matter of semantics. The word "race" normally connotes two or more contestants running on the same track, taking the same hurdles and trying to reach the same goal. In this case, we do not know precisely what course the opposition is taking, we do not know his specific goals, nor do we know how hard he is running. Moreover, in my opinion it would be a mistake, even if we did know, to pattern our every step after his. I think that we must set our own goals, point towards them with a broad, logical, scientifically sound program, and then run just as hard as we can. If in the process we achieve a significant "first", well and good, but it should be an outgrowth of our own sound program, not as our sole and primary goal.

The underlying philosophy in our vehicle development program rests upon three fundamental principles.

- First, we must create a fleet of standard vehicles with a minimum number of different designs and configurations. The inevitable limitation of dollars alone dictates that we must take this approach.

- Second, and closely allied to the first, we must attain a high degree of reliability through repetitive use of these basic vehicles, much as the automotive industry has achieved reliable cars through the millions of miles of driving on each of their standardized series.

- And third, to avoid early obsolescence, we must insure that each new vehicle we develop incorporates the most advanced technical approaches and growth potential consistent with the reliability we require.

As I have indicated, the first two of these principles - minimum variety and repetitive use of standardized vehicles - are dictated largely by economy. The costs of developing launch vehicles are already high and they are going up in a geometrical progression with every new, larger, and more advanced vehicle that we develop.

The need for reliability through repetitive use of the same vehicle is, I think, obvious. These devices, being essentially expendable, must function properly the first time or the entire cost of the operation is wasted. By using the same type of rocket vehicle over and over, rather than trying to use a variety of vehicles, each designed for a specific purpose, we build up our experience level on the vehicle, are able to detect and eliminate the "bugs" and the defects sooner, and consequently arrive at a high level of reliability earlier in our program.

Now let us look at our past, our present, and our planned fleet of vehicles to see how we are applying these operating principles. I'll try to make this summary as concise and straightforward as I can, but I guess I should warn you that it sometimes gets pretty confusing, even for those of us who work with it every day. The reason it is confusing is that up until now we have been forced, for lack of anything better, to work with a variety of vehicles which have been put together out of various components developed in our various ballistic missile programs and in the Vanguard satellite program. These are the ones that we are trying to phase out of our inventory and replace with four or five standardized vehicles.

Two of these early vehicles, which have already been retired, were the Jupiter C, which served us so well back in 1958 when we so greatly needed a U. S. satellite in orbit to repair, in some measure, our badly mauled prestige; and the Vanguard IGY satellite vehicle which, in spite of its troubles, more than earned its development cost in the information provided by the three scientific payloads it orbited.

Also due to be retired this year is the Juno II, based on the Jupiter IRBM, and the Thor-Able, based of course upon the Air Force Thor IRBM. The Thor-Delta, which is this same Thor-Able improved through various modifications including an accurate and flexible radio guidance system, will be used through 1961 in a 12-vehicle program but we plan no follow-on procurement beyond that.

All of these vehicles that I have mentioned will be replaced by two new vehicles. The first is the Scout, which is a small four-stage solid propellant rocket - and incidentally, when I speak of "stages" I am sure you know I mean individual rockets, piled one on top of the other and fired successively, in order to progressively increase the speed of the payload, which is on the top of the whole combination. The other is the Thor-Agena B, which is basically the same vehicle as is being used very successfully in the Air Force Discoverer program, which I am sure you have read about. The Scout was selected because of its relatively low cost, about $750,000 per copy; and the Thor-Agena B was chosen because of its combination of greater payload, flexibility of operation, and potentially high reliability.

As far as payload capability is concerned, the Vanguard and the Jupiter C could place in a 300 mile orbit about a 25-pound payload. The Juno II could perform the same mission with a 100-pound payload, the Thor-Able about 200 pounds, and the Thor-Delta configuration will more than double this performance with about a 480-pound capability for this particular mission. Of their successors, Scout can handle a 150-pound payload for a fraction of the cost of its predecessors, and the Thor-Agena B will be able to put 1,250 pounds in a 300 mile orbit.

This same Agena B second stage used on top of the Thor will also be used by NASA, as well as the Air Force, on top of the Atlas ICBM as a first stage. The Atlas booster used with the Agena B will increase our payload capability in a 300 mile orbit to about 5,300 pounds.

Later in 1961 we are scheduled to launch our first Centaur. The Centaur will be the first rocket vehicle to employ a high energy upper stage, using liquid H_2 and liquid O_2 instead of the kerosene and liquid O_2 we have used so far. The added thrust that we gain by using hydrogen as a fuel gives the Centaur half again the payload when used on a trip to the moon, which is one of its principal missions in the NASA program. For the first time, in Centaur, the U. S. will have a launch vehicle able to duplicate the payload capability of the Russian Sputnik vehicle.

In addition to the Scout, the Thor-Agena, the Atlas-Agena, and the Centaur, which will be used as standardized vehicles in our continuing program, the Saturn vehicle is being developed under the management of Dr. Wernher von Braun's group at the Marshall Space Flight Center. As most of you probably know, the Saturn first stage consists of a cluster of eight ballistic missile-type engines, with a total thrust of 1,500,000 pounds. On top of it we will use the two upper stages using the same hydrogen-oxygen engine being developed for the Centaur. When we get this Saturn C-1 vehicle, which is the initial version of Saturn, our payload capability gets a king-sized boost - to over 25,000 pounds in a 300 mile orbit.

In the second model of Saturn, called C-2, we will insert another stage using four 200,000 pound thrust LO_2 - LH_2 engines between the first and second stages of the C-1 version.

We have had a great deal of study and analysis in progress for the past year to try to define the vehicle which will follow the Saturn. The principal mission which we have used as an objective in these planning studies has been that of landing a manned spacecraft on the moon, then returning a 15,000 pound re-entry package to the earth. The study has followed two principal approaches. The first was what you might call the brute force attack, known as Nova.

There have been a lot of references to Nova, as a vehicle, in the press and elsewhere. Nova is not a vehicle - it is simply one of a number of possible vehicle configurations which we have considered for the use of the single 1,500,000 pound thrust engine which we now have under development. Under this brute force approach, six of these large $1\frac{1}{2}$ million pound thrust engines would be used in the first stage. Four hydrogen-oxygen stages could be piled on top of this big booster to give us the 15,000 pound payload that we need to return a man to the earth after landing on the moon.

In all of the vehicles I have mentioned, the propulsion system is based on existing engine concepts wherein highly concentrated fuels are mixed with an oxidizer and burned in a combustion chamber. The resulting high temperature gas is accelerated through a jet nozzle, thus producing the thrust required to propel the rocket. For the initial boost to break away from the earth's gravitational pull, we need this kind of extremely high thrust of relatively short duration. Once the vehicle is in space, however, the requirement reverses from high thrust of short duration to relatively low thrust for much longer periods of time. To meet this second requirement, we have initiated two advanced programs in propulsion. One is a nuclear rocket, in which a nuclear reactor, instead of chemical combustion, is used to heat the propellant and expand it through the nozzle. The other is a system employing electrical propulsion.

The encouraging results which were obtained from the initial nuclear rocket reactor test conducted by the Atomic Energy Commission last summer have stimulated our hopes that the large increase in efficiency which we get from using nuclear upper stages, with weights less than one-third that of conventional rockets for the same mission capability, can be acquired by the time our program has reached the point where we need something beyond Saturn. Toward that end, the NASA and the AEC are increasing the pace of the Rover program, as the nuclear rocket program is known, and we are aiming for an orbital flight test of a prototype nuclear rocket in 1965, on top of the Saturn as a launch vehicle.

The use of electrical propulsion appears to be somewhat further in the future, but it has some attractive features which appear to be uniquely applicable to the space program. In essence, an electric rocket consists of an electrical power generator and a device to convert this power into thrust. There are several methods of converting electrical energy to thrust, but all are based on a concept of accelerating electrically charged particles to produce the desired jet stream.

Both the electric and nuclear rockets show considerable promise for space application because of their relatively high specific impulses. This high specific impulse, or amount of thrust per pound of propellant, reduces the total amount of propellant required and thus provides more room for the engine structure and payload. It is in this area, particularly, that we hope to find a major breakthrough in our capabilities.

This, then, is a very brief resume' of some of the things we are doing. I have concentrated mostly on my part of the program, because it is the part, of course, with which I am most familiar. If there were time I would like to tell you more about the other parts of our program; how we integrate our work with the scientific community, largely through the Space Sciences Board which was created by the National Academy of Sciences, and with the Department of Defense military space program by means of a joint Activities Coordinating Board. I would like to tell you something of the joint programs we are developing with various foreign nations, and some of the problems involved in establishing and operating a world wide network for tracking and communications stations to obtain the information from our satellites.

I think, however, that I have probably taken all the time I should, and I would like to conclude with just one observation, and that is that in spite of all the criticism that NASA has experienced during its short history, I feel that we are on the right track. Although a broad-based program of this sort may not offer the immediate and dramatic appeal of the concentrated drive of our opponents, which is apparently oriented primarily to spectacular propaganda firsts, I feel that in the long run we will be further ahead. Our program is an aggressive one. It is based upon a sense of urgency, and we believe it to be logical and scientifically sound. I think it is a program in which you, as citizens, can have confidence, and in which, as time goes on, you can be justifiably proud.

No. 60-221

SCIENCE AND ENGINEERING IN THE SPACE AGE

Hugh L. Dryden
Deputy Administrator
National Aeronautics and Space Administration

(Luncheon talk, 1960 National Summer Meeting, Institute of the Aeronautical Sciences, Los Angeles, California, June 29, 1960)

Last week in Washington we began the initial discussions which in due course will result in a decision on the financial resources to be devoted to the exploration of the new frontier of space in the fiscal year beginning a year from now on July 1, 1961. The questions are familiar to you. What is the real value of the exploration of space? Does it have to be done now? Would it not be better to spend the money for additional medical research, medical care for the aged, aid to under-developed countries, or other more pressing needs? The answers to these questions are straightforward and understood by this audience. The exploration of space is essential to the welfare and security of the United States because of its contributions to scientific knowledge and advanced technology, which are the foundation of our national economic welfare, its contributions to national prestige, and its contributions to man's intellectual and spiritual development. It must be done now or the opportunity will pass to others with greater vision. This task must be assumed along with other essential tasks. To understand that these are the correct answers requires a knowledge of the true nature of space exploration and of the role of science and engineering in the lives of all of us today.

Space is the new frontier of our time and has all the characteristics of any frontier, including the difficulty of justifying to the public the resources needed to explore it. Perhaps many of you have read Ralph Cordiner's discussion of the new frontier in his lecture in the "Peacetime Uses of Space" series of the University of California. Let me repeat a portion of his remarks:

"The advanced industrial nations can now send objects off the planet into space. This new capability opens a whole new frontier to human exploration, development and use. At this stage, the new frontier does not look very promising to the profit-minded businessman, or to the tax-minded citizens. But then, so it must have seemed to the Greeks, when Jason returned from his exploratory trip into the Black Sea; or to the Phoenicians, when their first explorers returned from the wild and savage shores of the Western Mediterranean. Most of the Greek and Phoenician traders, in 1000 B.C., probably preferred to invest their money in a good safe cargo of grain or wine, shipped over familiar sea lanes to familiar markets. But apparently a few traders and later colonists had the vision to see possibilities where other men saw nothing." ...

"Every new frontier presents the same problem of vision and risk...Leif Ericson discovered America 500 years before Columbus, but apparently the Vikings did not have the vision to see anything worth while on that vast empty continent, and so history waited for another half millennium." ...

"Even in our time, we have had prominent men who stated that airplanes would never fly faster than sound, that intercontinental missiles could not be developed, and that space flight is nothing more than a comic-strip fantasy." ...

"It takes an immense effort of imagination for the citizens to see beyond these initial difficulties of opening a new frontier...But such an effort at prophetic imagination is what is required of us as citizens, so that we will not, like Leif Ericson, leave the making of the future to others."

There is little that I can add to this plea of Mr. Cordiner. We are at approximately the same stage in the exploration of space as the Wright Brothers were in the exploration of the air a few years after the first flight. In those days few people were interested in the fragile vehicles of extremely limited speed, altitude, and flight duration which were the ancestors of modern jet transports and military airplanes. In fact, as a nation, and to our shame, we were so uninterested that the Wrights took their invention to Europe. When World War I broke out, we had no airplanes of our own. We were compelled to build copies of airplanes of other nations while we frantically tried to catch up in a technology we had neglected as unimportant. Will this be our record in the development of spacecraft?

The exploration of space is not only the exploration of a new geographic frontier, if we may take liberties with the meaning of the word geographic, but it is also a challenging new frontier of science and engineering. It requires the most advanced scientific and engineering advances of our time. Detailed knowledge and quantitative data are needed on phenomena under extreme environmental conditions, extreme speeds, the extreme cold of outer space, the extreme heating of atmospheric reentry, the extreme vacuum of space, and under exposure to impact of meteorites, to high-energy radiation of all wave lengths, and to charged particles of a wide range of energies. The required life of equipment without maintenance is measured in years.

The distinction between science and engineering is hardly understood by the public. In general, the press, both newspaper and magazine writers, use the term science as a generic term covering all activities leading from an idea or concept to the creation and construction of a machine, building, or similar object. Dr. John Hrones, Vice-President of Case Institute of Technology for Academic Affairs, comments as follows: "The great engineering achievements of the past decade are always attributed to the scientists and the role of the engineer is never delineated. The development of the atomic bomb, the development of nuclear power, the development of the atomic submarine, and the development of satellites and space probes are always spoken of as scientific achievements where, in reality, they are major engineering accomplishments." "True enough," he continues, "science unlocked important secrets of nature to make them possible, but yet, the real achievement has been an engineering one."

J. H. Keenan states that the purpose of science is to know and understand nature, to bridge the gap between the known and the unknown, whereas the purpose of engineering is to use the resources of nature for social ends, to bridge the gap between the known and the desired. These definitions suggest the sequential course of "hardware" development which seems logical and which may have existed years ago, but not today, namely, that scientists explore and create a reservoir of scientific knowledge from which the engineer may withdraw raw material for application to creative development of "hardware." In the jargon of the automatic controls specialist, this open-end loop has long since acquired many feed-back circuits as engineering development suggested new areas of search for knowledge and provided new tools to aid in the search. Or, to change the metaphor to a chemical one, science and engineering are like components of an interacting solution of chemicals governed by the laws of chemical kinetics with reaction rates governed by the relative concentrations.

These interactions have stimulated intensive study of engineering education and changes in engineering practice. You will recall that during the war there arose developments in fields such as radar and nuclear energy, which were inherently engineering in character. However, there were few engineers then available who knew enough about the scientific advances to exploit them. In addition, engineering developments in hitherto unexplored fields were found to be necessary. Science and engineering became intermingled in a new breed of engineers, some being physicists and chemists who had absorbed engineering knowledge, some engineers from various backgrounds who became knowledgeable of nuclear physics and chemistry. The best qualification for the new tasks was a thorough knowledge of the basic principles of mathematics, physics, and chemistry. An engineer who understood the basic principles of heat transfer could apply them to many new technologies, to the cooling of a radar transmitter tube, a reactor fuel element, or even a satellite and its equipment in the space environment. Thus, less specialization and a greater integration of the basic scientific principles underlying all engineering application became the essentials for survival in a rapidly changing science and technology.

While nuclear engineering has been used for illustrative purposes, many of you have lived through similar experiences in aeronautical and guided-missile engineering. Space exploration continues this trend still further as every old branch of scientific knowledge and some new ones need to be represented. Space exploration, like the nuclear field before it, requires the close collaboration of scientists and engineers. However, the situation is in a sense reversed, or we may regard the feedback loop as more prominent than the direct circuit. In space exploration, extensive engineering developments of launch vehicles, spacecraft, and tracking and telemetry networks are necessary in order to enable scientists to gain new scientific knowledge of the space environment. More than 80 percent of our effort in NASA is devoted to these engineering developments. These engineering developments in turn are based on the work of many other scientists.

The present state of the art of space technology permits certain missions which have produced important new knowledge. The results give us a preview of potential returns from space exploration. For example, the meteorological satellite, Tiros I, made 878 trips around the earth in its first two months, producing more than 25,000 photographs of cloud formations. The value of these photographs to weather forecasting and to meteorological research greatly exceeded the advance estimates which were themselves very high. Storm centers and weather fronts are easily recognizable and accurately located. In the southern ocean areas where normally only a few scattered observations from ships are received, four storm centers were visible in a single pass. The structure of storm clouds disclosed by the pictures was hitherto unsuspected, spiral bands of clouds extending from the storm center like the arms of the spiral nebulae separated by alternate spiral bands completely free from cloud. Cellular and banded structures were disclosed in ordinary storms extending over thousands of square miles. The results, though fragmentary in coverage were so useful to forecasters that summaries of the results were made available to them as received.

Tiros I was the first crude form of meteorological satellite, stabilized by spinning, and obtaining pictures only in that part of the orbit where the television camera sees the sunlit portion of the earth. It weighs 270 pounds and travels in a nearly circular orbit at altitudes between 435 and 468 miles. Other meteorological satellites of more advanced design will follow.

If we are to make rapid and substantial progress with maximum assurance of success we must follow the same methods which were so successful in aeronautical and missile developments. There we found the need for broad programs of laboratory research and technological development to supplement flight experience. Priority needs to be given to those areas in which the present state of knowledge limits the performance which can be realized in flight missions.

I will not take time here to list these areas but rather to emphasize that these methods are characteristic of all important areas of industrial advance, and that the broad base of research and development contributes to our entire economic strength, cross-fertilizing many fields. It is this permeating effect of knowledge gained for space exploration on large areas of industrial development that makes space exploration so essential to national welfare. A scientist in Western Germany said to me: "If Germany is to resume its former role as a leading industrial nation, it must gain experience in the new frontiers of technology which have been stimulated by space activities, whether or not Germany ever sends a satellite into space. The same technology is required in many other industries if Germany is to compete in the markets of the world."

Technical progress in any specific field is normally evolutionary in nature, but there are occasional breakthroughs. These usually result from the simultaneous maturing of developments in a number of fields, often unrelated. Then some creative engineer notices that the integration of these developments makes possible the accomplishment of some task hitherto believed to be impossible.

Let us look at the development of the intercontinental missile which opened the door to space exploration. The principles of rocket propulsion were known to Sir Isaac Newton. Goddard demonstrated the major components of liquid fuel rockets over 30 years ago, actually using the fuels most commonly employed today. Von Braun and his associates in Germany in World War II completed the bold application of these principles to a practical propulsion system of twelve tons thrust. This development was essentially evolutionary in nature.

By contrast, the intercontinental missile combined a number of independent developments, including (1) the V-2 rocket engine, enlarged six-fold in size and refined in materials and structural design; (2) structural developments such as pressure stabilized thin-wall fuel tanks, integrally reinforced skin, and new welding methods; (3) inertial guidance systems of great precision; (4) light-weight nuclear warheads; and (5) new methods of dealing with the problem of aerodynamic heating on reentry, such as new blunt aerodynamic shapes, heat sink designs, new ablating materials, etc.

We may be confident that similar bold assemblies of developments in diverse fields to create new capabilities in space will take place in addition to the evolutionary advances, arising from the scientific research and engineering development reacting with each other and with flight experience.

Space technology is thus immersed in and a part of industrial technology developed for civilian and military purposes. It is in part an evolutionary extension and in part a carving out of new areas. Space activities will thus accelerate industrial progress in many ways, some foreseen, many unforeseen. Everyone knows the drive for miniaturization of electronic components to reduce weight and size for space application. We can foresee the pressure for electronic components to operate at very high temperatures, hundreds of degrees centigrade, and at very low temperatures. We can see wholly new developments of electronic apparatus in which elements operate in the hard vacuum of space without individual tubes or other enclosure.

We know that the improvements in materials required in space exploration will benefit many other applications. We foresee other applications of cryogenics, of new power sources. The discovery of methods of insuring long periods of unattended operation of mechanical equipment in space, the development of methods of lubrication in high vacua, the creation of new sensing and control devices, all will be used elsewhere. Medical research for space will aid in the protection of man in other environments. These are some of the most immediate returns of space exploration. In summary, both science and engineering will be stretched to and beyond their existing frontiers to meet the stimulating challenge of space exploration. As engineering is confronted with its task of attaining that which is desired, working from the existing reservoir of scientific knowledge, pressure will be exerted on science to close the gap between the unknown and the known in many areas. Engineering will furnish new tools to science to aid in the search for new knowledge; the greatest of these tools are satellites and space probes of greater and greater capability.

The exploration of space will thus give great impetus to the rapid advance of science and engineering, which are the very foundation stones of our current civilization. Space exploration will provide the means of accomplishing hitherto impossible tasks in our civil economy and for national security. Thus the exploration of space is not a luxury to appease the curiosity of a few scientists or to support the impractical ideas of a few "space cadets;" it is rather an activity essential to the continued progress, welfare, and security of the nation which must be prosecuted with continuity and vigor with the interest and support of the public.

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